Project Report: The Planetary Context of Biological Evolution: Permo−Triassic Mass Extinction and its Consequences

Lead Team:	***Harvard University***
Project Title:	***The Planetary Context of Biological Evolution: Permo−Triassic Mass Extinction and its Consequences***
Project Investigator:	***Andrew Knoll***

Project Progress

In this subproject, we seek to understand the causes and biological consequences of the great Permo−Triassic mass extinction, 251 million years ago.

During the past year, Erwin and Bowring have continued field and laboratory research on the nature, causes and timing of P−Tr mass extinction. Several descriptive papers were published on Permian and Triassic gastropods, and a model of recovery patterns was developed. Field work in China and South Africa is focusing on whether marine and terrestrial extinction pulses near the end of the Capitanian stage took place at the same time.

John Marshall and colleagues, including Co−I John Grotzinger, continue to model end−Permian oceanographic conditions, helping to constrain scenarios for the largest known mass extinction. They have shown that if ocean circulation were weaker than it is now, consumption of oxygen might outstrip oxygen supply to the deep oceans, leading to anoxic deep waters rich in dissolved carbon. Then, if a rapid change in circulation were to flush the deep ocean, bringing abyssal waters to the surface, the rapid release of carbon dioxide to the atmosphere could have a significant impact on biology, perhaps triggering extinctions. Current studies focus on the carbon isotopic signature expected for such a mechanism.

Postdoctoral fellow Kevin Boyce and A.H. Knoll completed work on late Paleozoic leaf evolution and continued (with colleagues at Carnegie) to explore microchemical techniques that provide insights into the physiology of early land plants. A paper demonstrating how X−ray microspectroscopy allows the detection of lignin−derived aromatic compounds in ancient tracheids has been followed up with a second paper showing that the conducting cells of early land plants were not lignified. Knoll also completed a paper with Richard Bambach quantifying the extent of change in marine community structure

associated with end−Permian and end−Cretaceous mass extinctions.

Highlights

- S. Bowring and D. Erwin are undertaking field work in South Africa to determine whether the first pulse of the P−Tr mass extinction was coincident on land and in the oceans.

- Modeling studies by John Marshall and colleagues indicate the range of conditions under which anoxic bottom waters could accumulate lethal amounts of carbon dioxide. Bottom water anoxia was much more likely in the late−Permian world than it is today, but biogeochemical tests are needed to confirm or reject numerical models.

- X−ray spectromicroscopy has enabled a Harvard−Carnegie team to characterize the organic composition of individual cells in distinct tissues of early land plants. This technology will enhance microchemical analysis of samples returned from Mars.

Roadmap Objectives

- ***Objective No. 5:*** Linking Planetary Biological Evolution
- ***Objective No. 12:*** Effects of Climate Geology on Habitability
- ***Objective No. 14:*** Ecosystem Response to Rapid Environmental Change

Mission Involvement

Mission Class*	***Mission Name (for class 1 or 2) OR Concept (for class 3)***	***Type of Involvement*** **
3	Mars sample return	Development of microchemical techniques for use in the search for biomarkers in Martian samples

* Mission Class: Select 1 of 3 Mission Class types below to classify your project:
1. Now flying OR Funded & in development (e.g., Mars Odyssey, MER 2003, Kepler)
2. Named mission under study / in development, but not yet funded (e.g., TPF, Mars Lander 2009)
3. Long−lead future mission / societal issues (e.g., far−future Mars or Europa, biomarkers, life definition)

** Type of Involvement = Role / Relationship with Mission
Specify one (or more) of the following: PI, Co−I, Science Team member, planning support, data analysis, background research, instrument/payload development, research or analysis techniques, other (specify).

When samples are returned from Mars, there will be a great need for microchemical techniques that can assay for organic biomarkers in very small

samples. With colleagues from Carnegie, our team has been demonstrating how elemental mapping by microprobe and microspectroscopy can identify potential biomarkers and, in addition, locate them within micron−scale regions of samples.

Field Expeditions

Field Trip Name: P−Tr boundary sampling in China	
Start Date: 01/15/2002	***End Date:*** 02/15/2002
Continent: Asia	***Country:*** China
State/Province: Jiangsu	***Nearest City/Town:*** Meishan
Latitude: 32 N	***Longitude:*** 117 E
Name of site(cave, mine, e.g.):	***Keywords:***
Description of Work: Collecting paleontological samples and ash beds to constrain timing of P−Tr extinction	
Members Involved: S. Bowring and D. Erwin	

Field Trip Name: Late Permian and P−Tr boundary sampling in South Africa	
Start Date: 06/05/2002	***End Date:*** 06/23/2002
Continent: Africa	***Country:*** South Africa
State/Province: Cape	***Nearest City/Town:*** Capetown
Latitude: 31 N	***Longitude:*** 19 E
Name of site(cave, mine, e.g.):	***Keywords:***
Description of Work: Collecting paleontological samples and ash beds to constrain timing of continental extinctions near end of Permian Period	
Members Involved: S. Bowring	

Cross Team Collaborations

Work by Knoll and Boyce on microchemical analyses of fossils is done in collaboration with R. Hazen, M. Fogel, and G. Cody of the Carnegie team.